## SIMULTANEOUS OCCURRENCE OF HALOS AND CORONAS

Dr. C. F. Brooks, in a short article published in the MONTHLY WEATHER REVIEW, January, 1919, **47**; 21, cites several cases in which lunar halos and coronas were visible at the same time. Starting with the assumption that coronas originate only from clouds formed of liquid particles, he admits that halos are due to clouds formed of solid particles; these, falling through an atmospheric stratum relatively warm, will pass into the liquid state; whence the origin of the corona. The author does not consider the possibility of supercooled water, nor the formation of coronas by transparent ice crystals.

The simultaneous occurrence of halos and coronas is a more frequent phenomenon than might be thought. In my researches on the frequency of halos I have found numerous cases of such simultaneity. But already Pernter in his "*Meteorologische Optik*," p. 424, cites 16 cases from observations from Ben Nevis, and 4 cases from the expedition of the "Belgica."

It is not necessary, therefore, to form any special hypotheses as to the physical state of the water, as Pernter demonstrates in the same work, p. 395,ffg., coronas may also form in clouds made up of particles in the solid state.—*Carlo Negro*, Torino, Italy. [Translation by *R. S. H.*]

*Discussion.*—Since the finest coronas are produced on clouds having temperatures far below the freezing point of water, Pernter assumed that such coronas were formed by the diffraction due to ice crystals. Simpson has pointed out, however (*Quar. Jour. Roy. Meteorological Soc.* 1912, **38**, 291–301), that the observations of the Ben Nevis and other meteorological logs referred to by Negro are merely cases in which coronas and halos were entered together, they do not prove that both were produced by one and the same cloud. Careful observations by Simpson while in the Antarctic failed to reveal a single instance in which a corona and halo were seen on the same cloud. Furthermore, his observations of a fog bow prove conclusively that liquid water droplets can exist at $-29°$ C., and there is no reason to believe that this is the lower limit; hence the high clouds on which coronae are observed do not necessarily have to consist of ice crystals. In addition, Simpson shows that ice clouds could not produce coronae at all, merely white light.

Some instructive notes on the existence of minute undercooled *liquid* droplets in the atmosphere, and their relations to crystallization, will be found in *Symons's Meteorological Magazine*, 1917, vol. 52, pp. 17–18, 31–32. (In this connection it may be stated that the present writer has been informed by a competent crystallographer that certain minerals are known in which the surface tension so far overbalances the force of crystallization, even in finite crystals, that crystals with plane faces can not be produced, and in one instance solid *spherical* crystals were obtained.)

It is evident, therefore, that the simultaneous appearance of a halo and a corona requires some special explanation, as in the observations cited by Brooks. This problem, it should be noted, is totally distinct and different from that treated by S. W. Visser in a very important paper "On the diffraction of the light in the formation of halos," Kon. Ak. van Wetensch. te Amsterdam, *Proc. Sec. Sci.*, 1917, 19, pt. 2, pp. 1174–1196 (See abstract in MONTHLY WEATHER REVIEW, 1918, **46**, 22.)—*E. W. Woolard.*

*Additional note.*—The simultaneous occurrence of a solar halo and corona, or coronae, does not appear to be a rare phenomenon when two or three layers of clouds are involved.

In fact, the frequency is nearly as great as the frequency of halos, although not usually observable without dark glasses or mirror, and, therefore, seldom noticed, and even less often recorded. Occasionally, once or twice a month, a halo may be seen in cirro-stratus cloud, the lower portions of which envelop a corona-forming alto-cumulus layer. The halo may be complete, or nearly so, and with practically undiminished brilliance where it passes in front of alto-cumulus masses; and the denser parts of the alto-cumulus layer cast long shadows down through the cirro-stratus. Although such a halo and corona are not in the same cloud, one cloud and part of the other occupy the same space.—*C. F. Brooks.*

## NOTES ON IRIDESCENT CLOUDS.

By S. FUJIWHARA and H. NAKANO.

[Abstracted from Journal of the Meteorological Society of Japan, June, 1920, vol. 39, No. 6, pp. 1–9.]

Pernter's theory of the diffraction of light by ice crystals would be valid if all the needles were so arranged that they had a definite direction, such as would happen if the cloud had some acceleration; this would, in general, be pretty rare, however.

Although the minute drops necessary for Simpson's theory of iridescent clouds are not included within the limits of sizes assigned by Pernter ($1\times10^{-3}<r<5\times10^{-3}$ cm.), the generalization by which Pernter derived these limits does not seem to be sound; and A. Wegener (*Met. Zeit.*, 1910, p. 354) has shown the possible existence of drops of radius $10^{-7}$ cm. If undercooling can take place to the extent postulated by Simpson, then the latter's theory can be correct. The irregular distribution of colors in iridescent clouds may be due to the irregular distribution of drops of various sizes.

Calculations of the lines of iridescence in the ideal cases of circular clouds and band clouds indicate that all observed hemming and crossing of clouds by color bands may take place with the proper distribution of suitably sized drops, such as presumably exists along the edges of forming or dissolving cloud. (See G. C. Simpson, *Quar. Jour. Roy. Meteorological Soc.*, 1912, 38, 291–301; C. F. Brooks, note below; W. J. Humphreys, *Jour. Franklin Inst.*, Nov., 1919, pp. 654–655.)

Furthermore, the cloud of vapor arising from a vessel filled with hot water shows beautiful diffraction effects when illuminated by sunlight, at angular distances up to 45°, proving the existence of sufficiently small drops. In this vapor, as along the edges of quickly forming (usually thin) clouds, the water drops are in an unstable state, and uniform in size within stratified layers. The violent turbulence, and formation of large drops, in a cumulus head explains why such colors are not observed in this case.—*E. W. W.*

## IRIDESCENT CLOUDS.

By CHARLES F. BROOKS, Meteorologist.

[Weather Bureau, Washington, D. C., June 26, 1920.]

Forming, lenticular clouds often show well-defined alternating reddish and bluish or greenish color bands parallel to the edge of the cloud, the innermost portion being perhaps lighted with a greenish or reddish sheen, or perhaps both irregularly intermingled, over a relatively large area. These colors are usually most brilliantly developed within 30 degrees of the sun but at times (as at Washington, D. C. at 2:05 p. m. June 23, 1920) may be discernible to a distance of more than 50 degrees.[1]

[1] Faint diffraction color bands were observed parallel to the edge of a lenticular cloud, about 55° from the sun, at 6:30 p. m., July 26, 1920.